Claims

1. A hot-rolled steel plate containing C of 0.03 to 0.1%, Si of 0.01 to 0.5%, Mn of 1.2 to 2.5% and Al of 0.08% or less by mass, wherein a metal structure is a substantially three-phase structure of ferrite, bainite, and island martensite, and an area fraction of the island martensite is 3 to 20%, in addition, the steel plate has any one of chemical composition conditions of the following (1) to (3) for precipitating a complex carbide in a ferrite phase:

(1) a condition where the steel plate further contains Mo of 0.05 to 0.4% and Ti of 0.005 to 0.04%, wherein the remainder is substantially Fe, and C/(Mo+Ti) which is a ratio of C amount to total amount of Mo and Ti in percent by atom is 1.2 to 3;

(2) a condition where the steel plate further contains Mo of 0.05 to 0.4% and Ti of 0.005 to 0.04%, in addition, contains Nb of 0.005 to 0.07% and/or V of 0.005 to 0.1%, wherein the remainder is substantially Fe, and C/(Mo+Ti+Nb+V) which is a ratio of the C amount to total amount of Mo, Ti, Nb and V in percent by atom is 1.2 to 3; and,

(3) a condition where the steel plate further contains at least two selected from Ti of 0.005 to 0.04%, Nb of 0.005 to 0.07% and V of 0.005 to 0.1%, wherein the remainder is substantially Fe, and C/(Ti+Nb+V) which is a ratio of the C amount to total amount of Ti, Nb and V in percent by atom is 1.2 to 3.

2. A hot-rolled steel plate containing C of 0.03 to 0.1%, Si of 0.01 to 0.5%, Mn of 1.2 to 2.5%, Al of 0.08% or less, Mo of 0.05 to 0.4% and Ti of 0.005 to 0.04% by mass, wherein the remainder is substantially Fe, and C/(Mo+Ti) which is a ratio of C amount to total amount of Mo and Ti in percent by atom is 1.2 to 3, and a metal structure is a substantially three-phase structure of ferrite, bainite, and island martensite and an area fraction of the island martensite is 3 to 20%.

3. A hot-rolled steel plate containing C of 0.03 to 0.1%, Si of 0.01 to 0.5%, Mn of 1.2 to 2.5% and Al of 0.08% or less by mass, and containing at least two selected from Ti of 0.005 to 0.04%, Nb of 0.005 to 0.07% and V of 0.005 to 0.1% by mass, wherein the remainder is substantially Fe, and C/(Ti+Nb+V) which is a ratio of C amount to total amount of Ti, Nb, and V in percent by atom is 1.2 to 3, and a metal structure is a substantially three-phase structure of ferrite, bainite, and island martensite and an area fraction of the island martensite is 3 to 20%.

4. The hot rolled steel plate according to any one of claims 1 to 3, wherein any one of the following complex carbides is precipitated in the ferrite phase:

(a) a complex carbide containing Ti and Mo, having grain diameter of less than 10nm;

(b) a complex carbide containing Ti, Mo, Nb and/or V, having grain diameter of less than 10nm; and,

(c) a complex carbide containing at least two selected from Ti, Nb and V, having grain diameter of less than 10nm.

5. The hot rolled steel plate according to any one of claims 1 to 4, wherein the steel plate further contains N of 0.007% or less by mass.

6. The hot rolled steel plate according to any one of claims 2, 4 and 5, wherein the steel plate further contains Nb of 0.005 to 0.07% and/or V of 0.005 to 0.1% by mass, and C/(Mo+Ti+Nb+V) that is the ratio of the C amount to the total amount of Mo, Ti, Nb and V in percent by atom is 1.2 to 3.

7. The hot rolled steel plate according to any one of claims 1 to 6, wherein the steel plate contains Ti of 0.005 to less than 0.02%.

8. The hot rolled steel plate according to any one of claims 1 to 7, wherein the steel plate further contains at least one of Cu of 0.5% or less, Ni of 0.5% or less, Cr of 0.5% or less, B of 0.005% or less, and Ca of 0.0005 to 0.003% by mass.

9. The hot rolled steel plate according to any one of claims 1 to 8, wherein the steel plate further contains Ti/N of 2 to 8 in percent by mass.

10. A welded steel pipe using the steel plates according to any one of claims 1 to 9.

11. A method for manufacturing a hot-rolled steel plate, having;

a process of hot-rolling a steel slab, which contains C of 0.03 to 0.1%, Si of 0.01 to 0.5%, Mn of 1.2 to 2.5%, and Al of 0.08% or less, and further has any one of chemical composition conditions of the following (1) to (3) to precipitate the complex carbides in the ferrite phase, at a condition of heating temperature of 1000 to 1300°C and rolling finish temperature of Ar3 or more;

a process of performing accelerated cooling to the hot-rolled steel plate to 450 to 650°C at a cooling rate of 5 °C/sec or more;

and a process of reheating the steel plate to 550 to 750°C at a heating rate of 0.5 °C/sec or more promptly after the cooling:

(1) a condition where the steel plate further contains Mo of 0.05 to 0.4% and Ti of 0.005 to 0.04%, wherein the remainder is substantially Fe, and C/(Mo+Ti) which is a ratio of C amount to total amount of Mo and Ti in percent by atom is 1.2 to 3;

(2) a condition where the steel plate further contains Mo of 0.05 to 0.4% and Ti of 0.005 to 0.04%, and contains Nb of 0.005 to 0.07% and/or V of 0.005 to 0.1%, wherein the remainder is substantially Fe, and C/(Mo+Ti+Nb+V) which is a ratio of the C amount to total amount of Mo, Ti, Nb and V in percent by atom is 1.2 to 3; and,

(3) a condition where the steel plate further contains at least two selected from Ti of 0.005 to 0.04%, Nb of 0.005 to 0.07% and V of 0.005 to 0.1%, wherein the remainder is substantially Fe, and C/(Ti+Nb+V) which is a ratio of the C amount to total amount of Ti, Nb and V in percent by atom is 1.2 to 3.

12. The method for manufacturing the hot-rolled steel plate in claim 11, a metal structure of the hot-rolled steel plate is a substantially three-phase structure of ferrite, bainite and island martensite, and an area fraction of the island martensite is 3 to 20%.

13. A method for manufacturing a welded steel pipe, having;

a step of hot-rolling a steel slab, in which C of 0.03 to 0.1%, Si of 0.01 to 0.5%, Mn of 1.2 to 2.5%, Al of 0.08% or less, Mo of 0.05 to 0.4% and Ti of 0.005 to 0.04% are contained, and the remainder is substantially Fe, and C/(Mo+Ti) which is a ratio of C amount to total amount of Mo and Ti in percent by atom is 1.2 to 3, at a condition of heating temperature of 1000 to 1300°C and rolling finish temperature of Ar3 or more;

a step of performing accelerated cooling to the hot-rolled steel plate to 450 to 650°C at a cooling rate of 5 °C/sec or more;

a step of reheating the steel plate to 550 to 750°C at a heating rate of 0.5 °C/sec or more promptly after the cooling;

and a step of forming a steel plate, in which a metal structure is a substantially three-phase structure of ferrite, bainite, and island martensite, and an area fraction of the island martensite is 3 to 20%, into a tubular shape in cold working, and then welding abutting surfaces to form a steel pipe.

14. A method for manufacturing a welded steel pipe having;

a step of hot-rolling a steel slab, in which C of 0.03 to 0.1%, Si of 0.01 to 0.5%, Mn of 1.2 to 2.5%, and Al of 0.08% or less are contained, and at least two selected from Ti of 0.005 to 0.04%, Nb of 0.005 to 0.07%, and V of 0.005 to 0.1% are contained, and the remainder is substantially Fe, and C/(Ti+Nb+V) which is a ratio of C amount to total amount of Ti, Nb and V in percent by atom is 1.2 to 3, at a condition of heating temperature of 1000 to 1300°C and rolling finish temperature of Ar3 or more;

a step of performing accelerated cooling to the hot-rolled steel plate to 450 to 650°C at a cooling rate of 5 °C/sec or more;

a step of reheating the steel plate to 550 to 750°C at a heating rate of 0.5 °C/sec or more promptly after the cooling;

and a step of forming a steel plate, in which a metal structure is a substantially three-phase structure of ferrite, bainite, and island martensite, and an area fraction of the island martensite is 3 to 20%, into a tubular shape in cold working, and then welding abutting surfaces to form a steel pipe.

15. The method for manufacturing the hot-rolled steel plate or welded steel pipe according to any one of claims 11 to 14, wherein when the steel plate or steel pipe is reheated, it is reheated to temperature at least 50°C higher than previously cooled temperature after the cooling.

16. The method for manufacturing the hot-rolled steel plate or welded steel pipe according to any one of claims 11 to 15, having;

a process of performing the accelerated cooling to the hot-rolled steel plate to 450 to 650°C at the cooling rate of 5 °C/sec or more to form a two-phase structure of non-transformed austenite and bainite;

and a process of reheating the steel plate to 550 to 750°C at the heating rate of 0.5 °C/sec or more promptly after the cooling to change the structure into a three-phase structure of a ferrite phase in which precipitates are dispersedly precipitated, a bainite phase and island martensite.

17. The method for manufacturing the hot-rolled steel plate or welded steel pipe according to any one of claims 11 to 16, wherein the treatment of reheating the steel plate to 550 to 750°C at the heating rate of 0.5 °C/sec or more promptly after cooling is performed with an induction heating device arranged on the same line as rolling equipment and cooling equipment.

18. The method for manufacturing the hot-rolled steel plate or welded steel pipe according to any one of claims 11 to 17, any one of the following complex carbides is precipitated in the ferrite phase:

(a) a complex carbide containing Ti and Mo, having grain diameter of less than 10nm, or

(b) a complex carbide containing Ti, Mo, Nb and/or V, having grain diameter of less than 10nm, or,

(c) a complex carbide containing at least two selected from Ti, Nb and V, having grain diameter of less than 10nm.

19. The method for manufacturing the hot rolled steel plate or the welded steel pipe according to any one of claims 11 to 18, wherein the plate or the pipe further contains N of 0.007% or less by mass.

20. The method for manufacturing the hot rolled steel plate or the welded steel pipe according to any one of claims 13 and 15 to 19, wherein the plate or the pipe further contains Nb of 0.005 to 0.07% and/or V of 0.005 to 0.1%, and C/(Mo+Ti+Nb+V) that is a ratio of C amount to total amount of Mo, Ti, Nb and V in percent by atom is 1.2 to 3.

21. The method for manufacturing the hot rolled steel plate or the welded steel pipe according to any one of claims 11 to 20, wherein the plate or the pipe further contains Ti of 0.005 to less than 0.02%.

22. The method for manufacturing the hot-rolled steel plate or welded steel pipe according to any one of claims 11 to 21, wherein the plate or the pipe further contains at least one selected from Cu of 0.5% or less, Ni of 0.5% or less, Cr of 0.5% or less, B of 0.005% or less, and Ca of 0.0005 to 0.003% by mass.

23. The method for manufacturing the hot-rolled steel plate or the welded steel pipe according to any one of claims 11 to 22, wherein the plate or the pipe further contains Ti/N of 2 to 8 in percent by mass.

24. The method for manufacturing the welded steel pipe according to any one of claims 11, 12 and 15 to 23, wherein the method has a step of forming the obtained steel plates into a tubular shape in cold working, and welding abutting surfaces to form a steel pipe.